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SUBJECT : MILITARY THOUGHT (SECRET): "Some Problems of Improving Wheeled Combat Vehicles for the Ground Forces", by Major-General of Engineer-Technical Service G. Zimelev, Engineer-Colonel A. Frumkin, and Engineer-Colonel V. Medvedkov

1. Enclosed is a verbatim translation of an article from the SECRET Collection of Articles of the Journal "Military Thought" published by the Ministry of Defense, USSR, and distributed down to the level of division commander.

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Richard Helms
Deputy Director (Plans)

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IRONBARK

Some Problems of Improving Wheeled Combat Vehicles for the Ground Forces

by

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As is known, the destructive factors of nuclear weapons are considerably greater than those of all known weapons of destruction used during the Second World War. By its nature, this circumstance has put special demands on all types of combat equipment used by the ground forces in order to ensure that they can carry on combat operations without interruption.

At present, the most stable and mobile vehicles are armored tracked vehicles of the tank type. However, full use of their striking power depends to a considerable extent on the combat and technical qualities of the wheeled vehicles of the ground forces.

Lately, in the press and at scientific conferences, methods of further development of wheeled combat equipment, and especially problems of creating an infantry combat vehicle have been widely discussed.

It is generally agreed that the combat vehicle must ensure that infantry can fight in coordination with tanks without having to dismount. As regards the design of such a vehicle, however, various opinions are expressed.

In this article we put forward our viewpoint regarding the prospects of creating wheeled combat vehicles for the ground forces.

What requirements must wheeled combat vehicles really meet? Because they operate in troop battle formations under the very same conditions as tanks, their mobility (cross-country ability is included in the meaning here) should be as good as that of tanks. Moreover, wheeled combat vehicles must provide protection for personnel to a definite extent against firearms and the destructive factors of nuclear weapons.

Armored cars, i.e., armored wheeled vehicles, equipped with guns or machine guns, made their appearance in the armies of various countries at the beginning of the present century. The rudimentary design of automobiles in general during that period could not ensure that they had the necessary tactical-technical features, especially the ability to cross roadless terrain. In the following years, the technical and, consequently, the tactical qualities of armored cars improved. However, the rapid development of tanks, which combine great striking power with high cross-country ability, diverted attention for a long time from the development of wheeled combat vehicles. It was only during the Second World War, after the appearance of reliable cars with increased cross-country ability, that several countries again started to construct armored cars, but only for the limited purpose of tactical employment.

In our army it was wrongly considered for a comparatively long time that it was possible to create wheeled combat equipment by fitting ordinary cars with armor. This completely, and for a long time, undermined the idea of using wheeled combat vehicles. A glaring example of this approach is the BA-20 armored car, created by fitting an armored body to the chassis of the M-1 automobile, and which earned such an unfortunate reputation in the army at the beginning of the war.

The extensive development of mechanized troops and the need to move them rapidly from place to place for operational and tactical purposes caused the appearance of military combat vehicles of a new type -- armored personnel carriers, which

have come into very extensive use in all the leading countries of the world since the Second World War. At the present time, considerable attention is being paid in several countries to working out new layouts and designs for armored personnel carriers.

In the USA, a number of wheeled armored personnel carriers are in the process of being developed and tested, including a heavy armored personnel carrier constructed in accordance with the so-called "Gerr idea." This idea is based on the use of vehicles consisting of a one-axle prime mover and a one-axle trailer with driving wheels. The large size of the wheels ensures that these vehicles have a high cross-country ability, while the hinged coupling between the forward and rear parts enables them to turn in a small space.

The British Army is equipped with the "Humber" two-axle armored personnel carrier and the three-axled "Saracen." On the three-axle chassis of the "Saracen" armored personnel carrier several modified vehicles have been produced, including the "Saladin" armored car and the auxiliary vehicles "Salamander" and "Stalwart."

The French Army is equipped with wheeled and tracked armored personnel carriers. Of the wheeled type, the one of most interest is the four-axle "Panar" armored personnel carrier with a combat weight of 13.5 tons, which has fairly strong armor and is intended for transporting 15 persons. The layout of the armored carrier is an original one: the air-cooled engine of 200 hp is in the middle of the vehicle and the transmission has side distribution of power (bortovaya razdacha moshchnosti). The wheels of the second and third axles with prominent metal spuds (razvityy metallicheskiy gruntozatsep) are lowered to the ground when the vehicle has to move over difficult terrain. The "Panar EBR-75" armored car, equipped with guns and machine guns, is produced on the same chassis.

The West German Army is being equipped with a light two-axle wheeled "Unimog" armored personnel carrier with a combat weight of 7 tons, which has bulletproof armor plating and is intended to carry 4 or 5 persons. According to the requirements laid down by the West German Ministry of Defense, there are to be two types of armored personnel carriers in service: light - with a combat weight of 10 tons and carrying capacity for 5 persons, and heavy - with a combat weight of 15 tons and carrying capacity for 10 persons; the armor must provide frontal protection against bullets and shells up to 20 mm in caliber.

The direction which development of armored personnel carriers is taking abroad points to a trend to have them not only for the purpose of transporting infantry, but also in the role of combat vehicles on the battlefield.

From this viewpoint, the choice of the most efficient types of wheeled and tracked vehicles for combat use under various conditions now becomes a fairly acute problem. Until quite recently the opinion was held that for direct coordination with tanks, it was supposedly best to use tracked armored personnel carriers. But in doing so, as is known, two main difficulties arise. Firstly, a modern army requires tens of thousands of combat vehicles, and the provision of such expensive equipment is a heavy burden on the country's economy. Secondly, the reliability and durability of tracked vehicles, especially of their running gear, are still far from adequate.

For these reasons, greater attention is now being paid to introducing wheeled combat vehicles into the army. This is facilitated by the considerable improvement in their tactical-technical qualities, which has been achieved as a result of extensive tests. The latest wheeled combat vehicles have, in practice, just as good a cross-country ability as tanks, and at the same time have a number of advantages over tracked vehicles. These advantages are:

— they can be turned out by the automobile industry, and this ensures the possibility of mass production, and at a comparatively small cost per vehicle;

— the increased reliability and durability of wheeled vehicles as compared with tracked ones, particularly their engine and transmission, which are 3 to 5 times more reliable and durable, and their running gear — 15 to 20 times;

— their greater (by 50 to 60 percent) speed and greater range;

— when their carrying capacity is the same, wheeled combat vehicles use 40 to 50 percent less fuel for carrying one soldier than tracked ones;

— the metal content of wheeled combat vehicles is 30 to 40 percent less;

— they make comparatively little noise when moving;

— they do less damage to roads.

Until recently, one of the most vulnerable parts of wheeled armored personnel carriers was their pneumatic tires, damage to which put the vehicle out of action. Now, however, the tubeless tire system (sistema tsentralnogo regulirovaniya vozdukha v shinakh) has increased the life of the vehicle on the battlefield to a considerable extent. Numerous tests have shown that thanks to this system tires are not put out of action even when hit by many bullets and the wheeled combat vehicle can continue to carry out its task. But this is, of course, not the only resolution to the problem of increasing tire life.

It is necessary to add that the armored personnel carriers developed in the postwar period and now in service do not meet modern battle conditions. They are only capable of "transporting" infantry because the infantry cannot fight from them without dismounting.

The highly mobile operations of the present day, especially on ground contaminated by radioactive substances, make it necessary to develop a vehicle that can be used for waging combat together with attacking tanks.

On the basis of tactical, technical, and economic considerations let us analyze the basic requirements that a modern wheeled combat vehicle for ground forces must meet.

Protective characteristics and combat weight. The relationship between the protective characteristics of tanks and wheeled combat vehicles must be determined, firstly, by the nature of their tactical and operational employment, and, secondly, by considerations of technical expediency. It is essential to find a solution which would provide for the necessary degree of protection and ensure that the vehicle is highly mobile. The protective characteristics of a wheeled vehicle, determined by the thickness of the armor, are inferior to those of tanks; consequently, the reliability of wheeled combat vehicles must be increased not only by improving the armor protection, but also by making the vehicle more mobile.

The wheeled armored personnel carriers in service in the Soviet Army have only bulletproof armor 10 to 13 mm thick in the case of the hull front plates (lobovoy list) and 6 to 10 mm thick in the case of the hull side plates (bortovoy list). Such armor gives frontal protection for the vehicle against armor-piercing bullets of 7.62, 12.7, and 15 mm caliber at ranges of over 400 m. The side plates give protection against bullets of the above-mentioned calibers at ranges of 400 m when the angles of impact are 22 to 45°. Furthermore, it should be added that the majority of armored personnel carriers in service have bodies of the open type, made without taking into account the destructive effects of nuclear bursts.

In our opinion, the way in which wheeled combat vehicles are to be employed calls for strengthening the armor to afford protection against armor-piercing bullets from large-caliber machine-guns at all ranges when the angle of impact is ± 45°. Abroad there are wheeled combat vehicles which have frontal armor 40 mm thick, and side armor 16 mm thick, and this fully meets these requirements.

An analysis of the weight data of a great number of the available wheeled combat vehicles shows that the distribution of weight is characterized by the following average indices. The armored body accounts for 20 to 30 percent of the total combat weight. The crew and personnel carried (desant) account for 15 to 20 percent, the engine mount 5 to 10 percent, the transmission 12 to 15 percent, the running gear 12 to 15 percent, and the armament and additional equipment 10 to 20 percent.

When bodies of an efficient kind are used, an increase in the thickness of the hull front plates to 30 to 40 mm and of the hull side plates to 12 to 15 mm will result in an increase of the proportion of the body weight of up to 40 to 50 percent, if the possibility of using armor made of the latest materials is not taken into consideration.

On an average, an increase in the thickness of armor protection by 1 mm leads to an increase in weight of 200 to 250 kg for vehicles weighing 5 to 7 tons and of 350 to 400 kg for vehicles weighing 10 to 12 tons. Consequently, an increase in the thickness of the armor by 1 mm raises the total weight of a wheeled combat vehicle by 3 to 3.5 percent. Bringing the thickness of armor plate up to dimensions affording protection against armor-piercing bullets of large-caliber machineguns at all ranges leads to an increase in the weight of light combat vehicles by 800 to 1,000 kg, and of medium ones by 1,200 to 1,600 kg., and this calls for a corresponding increase in the engine's power in order to retain the essential traction capability.

An increase in the thickness of the armor plates of the body improves at the same time its ability to resist the destruction effects of a nuclear burst.

The wheeled armored personnel carriers now in service suffer medium damage when they are at a distance of 1,000 m from ground zero of the burst of a warhead with a TNT equivalent of 30,000 tons. When such damage is done, the armored personnel carriers cannot continue to fulfil their allotted tasks. If the combat effectiveness of a wheeled combat vehicle capable of remaining in action at a distance of 1,000 m from ground zero of a burst is to be achieved, then the thickness of the armor and the toughness of a body of closed type must be such as to withstand the pressure of a shock wave equal to 0.8 kg/cm^2. This

means that the vehicle's body must have armor plates 25 to 35 mm thick.

In existing armored personnel carriers, the personnel carried and the crew will get the maximum permissible dose of radiation with the burst of a nuclear warhead with a yield of 30,000 tons when they are at a distance of 1,500 m from the ground zero of the burst. Any significant reduction of the safe distance involves a sharp increase in the thickness of the plates of the armored body. It is also possible to make use of special "lining" (podboy) for facing the inside of the body; this, however, leads to a considerable increase in weight and, furthermore, reduces the inside capacity of the body.

Under modern conditions, it is of special importance that wheeled vehicles should be able to move over contaminated terrain. Ground forces may encounter extensive zones of unbroken radioactive contamination. The level of radiation in them will reach 100 to 200 r/hour. The armored personnel carriers which we have at our disposal, including those with closed-type bodies, are badly adapted for crossing such zones of contamination. It is impossible to achieve a sharp reduction in the radiation dose which the personnel carried and crew get, by increasing the speed with which wheeled combat vehicles move through contaminated zones. Reliable protection for the crew and the personnel carried can only be provided by a closed, hermetically sealed body, fitted with filtering and ventilating equipment and means for detecting radioactive elements and toxic substances. At the same time, one must have air conditioning (mikroklimaticheskoye usloviye) inside the vehicle's body so that human beings can remain there for a long time.

Everything connected with the improvement of the protective characteristics of a wheeled combat vehicle is limited by weight parameters. Up to the present time, there is no clear understanding of what the maximum weight of a wheeled combat vehicle can be. Many arguments are going on as to whether it is really possible to make a wheeled vehicle with armor protection which is not inferior to that of tanks.

Basically, the weight of a wheeled combat vehicle is limited by the maximum load on each wheel; when the size of the wheel is satisfactory, the load must ensure a specific pressure at the point of contact between the wheel and the ground which is not greater than that of tanks. If we take the permissible diameter of a wheel as 1.5 m and the specific pressure as not more than 0.7 to 0.8 kg/cm^2, it can be calculated on the basis of experimental data that for the existing makes of tires the permissible load on them must not exceed 3,000 kg. Because a wheeled combat vehicle must be highly mobile, be of an acceptable size, and have not more than four axles, its maximum weight can be about 24 tons. The average thickness of the armor of a wheeled combat vehicle of such a weight, intended for 20 persons, can be up to 40 mm, and when intended for 10 persons - 70 mm. When armor of varying thicknesses is used, however, the thickness of the hull front plates can go up to 90 to 130 mm.

Carrying capacity and specific indices. A wheeled combat vehicle's efficient carrying capacity is determined jointly by tactical, technical, and economic factors.

In the first place, one must take into consideration the way in which wheeled combat vehicles are to be used in tank and motorized rifle units. It is obvious that the number of wheeled combat vehicles in tank units must be such as to ensure that all the motorized infantry can go into the attack at the same time as the tanks. Moreover, one must be guided by the consideration that for convenience of control in battle, there should only be a single subunit (for instance, a squad ((otdeleniye))) inside the vehicle. Evidently, the most advisable type for tank units, taking into account the establishment strength of motorized infantry in them, is the combat vehicle intended for carrying one squad of motorized infantry. Such an infantry combat vehicle can be employed successfully for carrying out combat tasks in combined attacks with tanks, for conducting reconnaissance, for protection duties, for transporting communications officers into combat, and for other forms of combat activity. As for the construction of the running gear, such a vehicle can also be of the wheeled-tracked type, where the engine for the tracked gear is an auxiliary one and is switched on only when broken ground has to be crossed.

For various military purposes, it is desirable to have a combat vehicle of large carrying capacity, for example, for two squads. This would allow one to reduce the length of columns on the move and would simultaneously create the necessary conditions for dispersal. A vehicle of such a type could be used successfully as a control vehicle in large units and formations, and also as an ambulance.

From the technical viewpoint, too, it is advisable to increase the carrying capacity of wheeled vehicles to certain limits, because an increase in the capacity has a favorable effect on a whole number of technical-economical indices. For instance, there is a decrease in the specific metal content, i.e., the relation of the actual weight of the vehicle to the crew and personnel strength carried. When the capacity is 5 to 7 persons, the expenditure of metal per soldier amounts to 1,000 to 1,200 kg, whereas for 15 to 22 persons it decreases to 350 to 500 kg. This ratio can vary depending on the armor, the armament system, etc. For instance, the high specific weight of the French "Panar" armored personnel carrier (800 kg per man) is due to its comparatively strong armor.

An analysis of the weight parameters of existing armored personnel carriers shows that the actual weight of the vehicle does not increase in direct proportion to an increase in carrying capacity. On an average, it can be reckoned that when the capacity is increased three times, then the weight will increase about twice.

An increase in carrying capacity also has a favorable effect on such indices as the specific length and the specific over-all bulk. In combat vehicles for 3 to 5 persons, the specific length is equal to 1 to 1.1 m/person, whereas when the capacity is 20 to 22 persons, this figure falls to 0.3 to 0.35 m/person. In an efficiently designed wheeled combat vehicle, it can be reckoned that when the attacking force (desant) is carried in two rows, the specific length approaches half the width of the seating area.

When the vehicle's carrying capacity is increased, its over-all length also increases, and this leads to a deterioration of the parameters characterizing the vehicle's mobility. Consequently, from the technical standpoint there are limitations on the efficient carrying capacity, which is determined by the permissible over-all length dimensions of the vehicle. Designing experience shows that the maximum over-all length of a vehicle falls within 7 to 7.5 m and its maximum capacity is 20 to 25 persons.

In determining the most efficient carrying capacity from the economic standpoint, it must be borne in mind that when the capacity is increased, the specific cost per soldier decreases. If a comparison is drawn as an example between the cost of two combat vehicles for 10 persons, each weighing 5 tons, and one vehicle which can carry 20 persons, then the cost of the latter will be less, because there will be fewer engines and other basic parts. Furthermore, the weight of one wheeled combat vehicle of large carrying capacity will be 20 to 30 percent less than the total weight of two military vehicles with the same capacity. This makes the difference in the economic indices even greater.

Armament. Until recently the armored personnel carriers in the Soviet Army either had no organic armament (BRDM) or were armed with 7.62 mm machineguns. Such a state of affairs does not meet modern requirements. If one looks upon the wheeled vehicle as a fighting one, capable of engaging enemy personnel and of delivering strikes against enemy objectives of armored equipment, it is essential to strengthen its armament. To fulfil the allotted tasks, in our view wheeled combat vehicles must have as their main organic armament guided antitank missiles to combat enemy tanks, as well as large-caliber machineguns or small-caliber automatic guns. However, in order to mount armament of this kind, the over-all height of the vehicle would have to be considerably increased for the installation of a turret, in which the armament is mounted and the gunner is located. Therefore, the most efficient solution should be considered that of using a revolving turret of small over-all dimensions simply for holding the armament and the appropriate sighting apparatus, while control of the armament and conducting of fire must be by remote control.

Another solution can be that of installing a special turret of the usual size, but which could be lowered when it is necessary to reduce the over-all height of the vehicle..

Engine and dynamic qualities (dinamicheskoye kachestvo). The engine determines the dynamic qualities of the wheeled combat vehicle, and the position of the engine - its layout. Up to the present, in our armored personnel carriers use is being made of truck engines of somewhat increased power. Their specific power is 12 to 18 hp/t, the second figure applying to the latest vehicles. The amount of specific power determines the vehicle's maximum speed and, consequently, influences the vehicle's average speeds and acceleration. If we assume that modern wheeled combat vehicles should have a maximum speed of 100 kph, then the specific power must fall within the range of from 18 hp/t for heavy vehicles (combat weight 20 tons) up to 27 hp/t for light vehicles (combat weight 5 tons). Such power fully ensures good acceleration and average speeds of 50 kph.

In view of the lack of automobile engines of high power, two engines of medium power are sometimes installed in order to improve the vehicle's dynamic qualities. This is a solution born of necessity. It is not an efficient one either from the economic standpoint or that of the layout. In this case steering becomes more complicated, and the amount of technical servicing that has to be done increases. The only advantage of such a solution lies in some increase in the vehicle's life, because in case one of the engines is damaged or falls into disrepair, the vehicle can continue to move.

To create a combat vehicle with the optimum dynamic and design qualities, it is necessary to develop special engines.

The fact that engines need different kinds of fuel presents a serious problem. The resolution of this problem would make it possible when necessary to use a single kind of fuel for wheeled combat vehicles and tanks and would simplify problems of supply and the refuelling of vehicles operating in the depth of the enemy's defense.

It must be added that in foreign armies multifuel engines are in practical use. For instance, all West German military vehicles which have a tonnage of 5 tons and more are equipped with multifuel engines. For vehicles of lesser tonnage, such engines are in the process of being developed. In the USA the firm "Continental" has built a multifuel engine of 140 to 180 hp which is intended for installation in wheeled vehicles. In France, a series of multifuel engines in power ranges from 60 to 700 hp has been developed.

In view of the modern demand that wheeled combat vehicles should be amphibious, one must reckon that in the future the engine must be located at the rear, while the driving compartment and the compartment for the attacking force must be in the central part of the vehicle's body. Such a layout ensures a stable stern-heaviness (stabilnyy different na kormu) because a varying load (the attacking force) in this case does not change the position of the center of gravity along the vehicle's length to any great extent. When the engine is at the rear, if necessary the attacking force can leave the vehicle safely over the side through open protective hatches on the armored roof.

Mobility and cross-country ability. As has already been mentioned, the mobility and cross-country ability of wheeled combat vehicles must not be inferior to that of the tanks with which they cooperate. This means that the vehicle must move with confidence over soft ground and broken country and, like tanks, must be able to overcome various obstacles.

Can such requirements be met in the light of the modern development of wheeled vehicles? At the present time world industry is solving this problem in two ways. Firstly, it is being done by bringing the traditional designs of wheeled, mainly four-axle, vehicles to a high state of perfection, and secondly, by working out designs involving basically new layouts, which ensure high qualitative indices, as for instance "Hower," "Metrak," and others. From the standpoint of mobility and cross-country ability, some models of wheeled equipment now not only come up to but surpass the indices of tracked vehicles.

A modern four-axle vehicle can ensure a specific pressure at the point of contact between the wheel and the ground of 0.7 to 0.8 kg/cm^2 and even less, and this enables the vehicle to move reliably behind tanks over soft ground, especially if the track of the wheeled vehicle corresponds to that of the tank.

A wheeled four-axle vehicle can cross pits and trenches on the battlefield up to 2.5 m in width. The upward and downward slopes that it can cope with are the same as those surmountable by tanks. The ratio of weight to bulk in wheeled combat vehicles makes their conversion to amphibious vehicles a comparatively simple matter.

The only way in which wheeled vehicles have proved inferior until now to tracked ones is in their turning ability. A wheeled vehicle requires a considerable space in which to turn, and, in order to eliminate this shortcoming, use has been made of a large number of wheels which can be steered or of two steering positions, and sometimes a combination of the two. Such a solution has complicated the design, and it still has not done away altogether with the difference in turning ability between wheeled and tracked vehicles. At the present time, various methods of turning wheeled vehicles are being used: either like those in tanks ("Metrak," "Terrapin") or in accordance with the principle used in "Goer" vehicles.

In conclusion, it can be stated that in order to ensure successful operations by ground forces in highly mobile operations of short duration, it is essential to have new wheeled combat equipment which should be developed mainly on the lines given by us above. The present level of industrial production in the Soviet Union, and in particular of the automobile and tractor industry, allows a start to be made now to create special wheeled combat vehicles for the ground forces.

It is necessary to bear in mind the possibility of developing in the future combat vehicles of other designs, for instance air-cushion vehicles. The problems connected with their development merit separate examination.

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